To: FAME project
From: J.D. Phillips
Subject: FAME error budget, outline form
Date: 24 Oct., 2000 D:\U\USNO-AST\Error\outline2.wpd

This is the FAME error budget, in outline form. I solicit comments, and in particular effects I haven't thought of. It is not yet divided into significant and insignificant effects. Items marked with a pound sign (#) are candidates for moving to the list of insignificant effects.

I. "Centroiding" stage

A. Photon statistics.
B. Blurring effect of jitter in rotation and onboard clock.
C. Charge spreading in CCD
D. Read noise & dark current.

II. Spiral reduction stage. Many of these errors do not change significantly from one spiral to the next, thus it may be better to estimate them over a longer time scale, perhaps in the global reduction. Also, some may be so well known from pre-launch or ancillary data that they can be corrected for without use of the astrometric data at all.

A. CCD Errors.
    1. QE variations.
        a. Intra-pixel variations that move with accumulating charge.
            (1) Wavelength-dependence.
        b. Non-linearity.
        c. Bad pixels & columns.
    2. Detection of photons in the wrong pixel.
        a. Beam non-perpendicular, with wavelength variation of absorption.
        b. Dependence of Modulation Transfer Function (MTF) on wavelength.
        c. Fringing (in red).
    3. Charge transfer effects.
        a. Charge traps.
            (1) Image area
                (a) Si-E centers, others w/ τ>30(?) msec.
                (b) Divacancies and A-centers, others w/ τ<30 (?) µsec.
                (c) Medium-life traps
            (2) Serial register (same for all obs. behind affected SR pixel)
        b. Along-column bleed when approaching full-well.
    4. Electronics. Roundoff error #
    5. Physical flatness #
    6. Recovery from saturation #

B. Incorrect stellar spectrum model.
    1. Metallicity
    2. Reddening.
    3. Non-stellar objects.

4. Unmodelled blurring (see effects under I., "Centroiding stage")

C. Optics.
    1. Distortion
        a. Element shape, spacing, and orientation changes.
            (1) Changes of temperature and gradient.
            (2) Long-term drift, e.g., water loss
    2. Basic angle changes.
    3. Gain variation between columns with a skewed PSF changes emphasis on advanced portion of the wing of the image.
    4. Need to determine the PSF.
        a. Variation with field, wavelength, time.
    5. Non-uniformity of mirror reflectivity varies with time (and PSF is not symmetrical.)
    6. Temperature difference in CCD cover, combined with dn/dT.
    7. Contamination of CCD or its cover.
    8. Cosmic rays #
    9. Scattered light #
    10. Ghost images #

D. Rotation and onboard clock error.
    1. Image offset due to spin rate changes.
        a. Solar radiation variations.
        b. Solar wind.
        c. Viscosity of station-keeping fuel slows the rotation.
        d. Patch on the solar shield has different reflectivity.
        e. Earthlight shining in ports - variable torque.
        f. Motion of heat pipe working fluid, if one were to be used.
        g. Thermal expansion of spacecraft.Consider radiator plates, e.g., 3 looking out the sides, seeing the Earth.
        h. Nutation damper stiction (the damper must be linear down to very small displacements).
    2. Direction of image motion.
    3. Onboard clock error.

III. Uncategorized errors.
A. Imperfectly-determined "grid".
    1. Rotation spiral model errors. (This has no *a priori* component.)
    2. Global model errors. (This has no *a priori* component.)
B. Ephemeris.
C. Detected companions.
    1. Resolved.
    2. Unresolved.
D. Undetected companions.
E. Stellar activity.